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ABSTRACT

Recommended for grades 7-12 language arts, science, and social studies classes, this 5-7 day unit encourages students to investigate alternative energy sources through research. Focusing on geothermal energy, tide and ocean, fusion, wind, biomass, and solar energy as possible areas of consideration, the unit attempts to create an awareness of the barriers to overcome in the development of these energy sources, possible environmental consequences, and the probable time needed in the development of the new technologies. Each activity in the unit, focusing on a particular energy source, contains an introduction, the environmental effect that the source will have, and questions for investigation. Students are also asked to research information and prepare a report on a selected energy source. Rationale, objectives, and instructional strategies are provided for each activity. A list of process skills fostered, advanced teacher preparation, goals and objectives, and planning guide are also provided. (Author/JN)

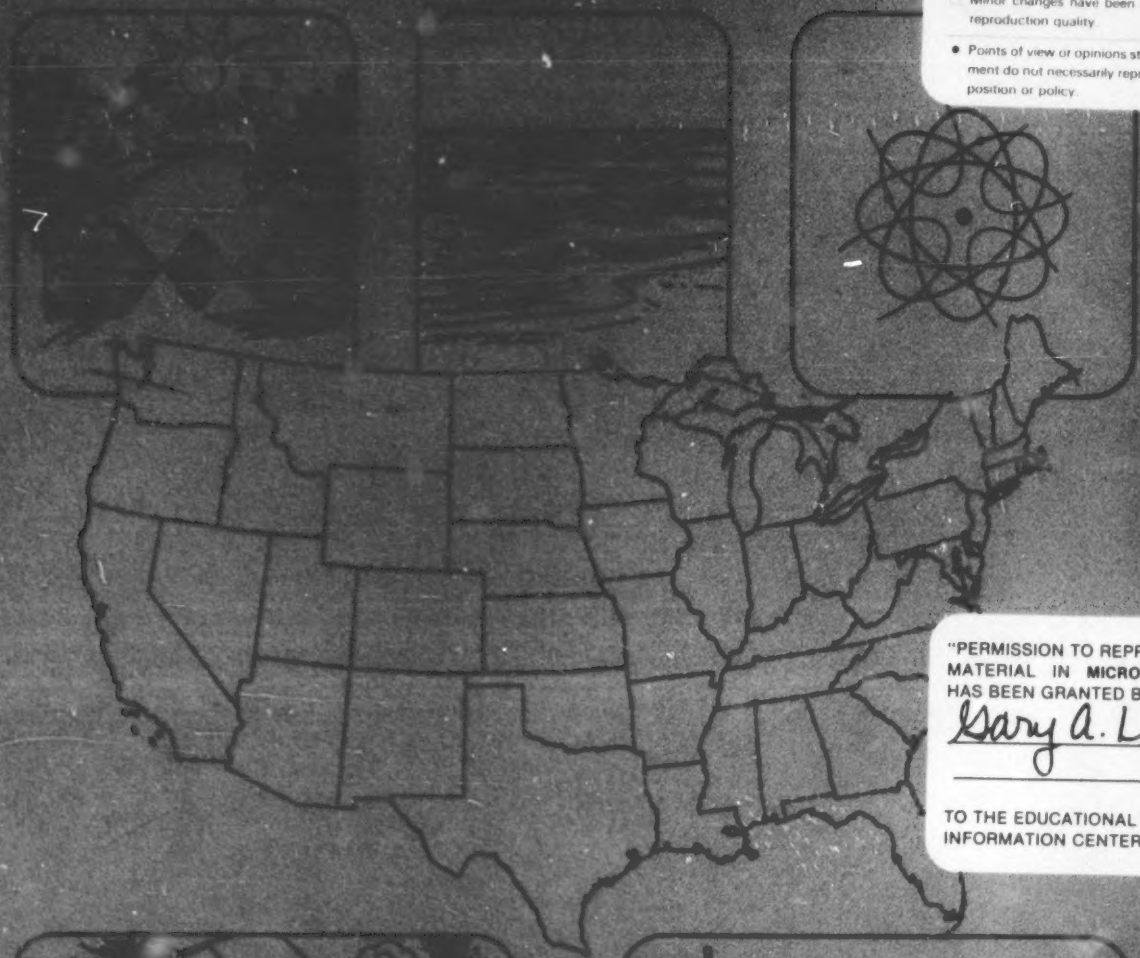
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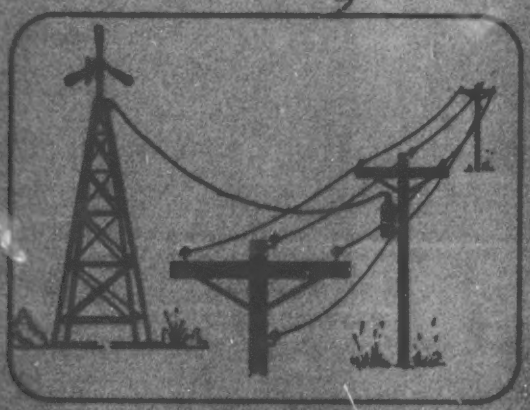


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FUTURE ENERGY TECHNOLOGY

Original Writer

Patrick McGill

Recommended Level: Junior or Senior High School Language Arts, Social Studies, Science

ACKNOWLEDGEMENTS

The original "Basic Teaching Units on Energy" consisted of a package of 30 instructional packets contained within three volumes. The original fourteen units were written at the University of Nebraska-Lincoln, under the auspices of the Nebraska Energy Office, by Nebraska teachers participating in a three-week Faculty Development Institute sponsored by the U.S. Department of Energy (summer, 1978). The units were edited by the following individuals:

—Dr. Donald McCurdy, Professor of Science Education, University of Nebraska-Lincoln;
—Mr. Gary A. Lay, Education Coordinator, Nebraska Energy Office; and
—Dr. Robert Reeder, Science Department Chairman, East High School, Lincoln, Nebraska.

An additional eight units were written by independent authors in the summer of 1979 and the final eight units were developed as a result of a second federal grant (summer, 1980).

The present format has been achieved as a result of an evaluation conducted by the Nebraska Energy Office, February, 1981. Rather than continue to offer all 30 units as a single package, the Nebraska Energy Officer determined to revise, edit, and typeset the 10-12 highest quality units and continue to offer the other units in their present format.

The editors of these revised "Basic Teaching Units" wish to thank the individual writers, original editors, and clerical staff for their contributions in creating the "Basic Teaching Units".

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TO THE INSTRUCTOR . . .

"Future Energy Technology" is a unit designed to encourage students to investigate alternative energy sources through research. This particular unit lists the areas of geothermal energy, tide and ocean, fusion, wind, biomass, and solar energy as possible areas for consideration. There are many other alternative energy topics which have not been included in this unit but can be easily incorporated.

The format for each particular energy source is similar so that if additional topics are to be researched, students **could** adopt the same format. As is true of each activity, these are only suggested ways to investigate alternative energy sources. They must be adapted for each instructor's purposes according to the needs of students.

Another important aspect to facilitate success of this unit is the availability of multiple resources and materials. Encyclopedias can be used but there are pamphlets and articles available which may provide more recent and pertinent information. A class project may consist of writing letters to various organizations seeking these materials.

Finally, since material sources continue to change periodically, the source, **Energy Info—A Directory of Publications and Audio-Visual Materials from the Nebraska Energy Office**, contains a list of general topics and materials available from the Nebraska Energy Office. You are encouraged to use the ordering page attached to this unit to obtain this booklet as well as other energy related materials.

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FUTURE ENERGY TECHNOLOGY

Abstract

It is a fact that fossil fuel energy resources are finite. Even with drastic conservation measures they will be depleted in the not-to-distant future. Since it was technology that created the tremendous demand and use of fossil fuels, many people look to technology, often unrealistically, to rescue us from the dilemma of dwindling fuel supplies and increasing energy demands.

This unit will examine some of the more promising energy technologies of the future and in so doing, attempt to create an awareness of the barriers to be overcome, the possible environmental consequences, and the probable time needed to sufficiently develop these technologies.

Each suggested energy source contains an introduction, the environmental effect that source will have, and questions for investigation. It also asks students to research information to compose a report on a selected energy source.

Recommended Level

Grades 7-12

Academic Areas

English, Science, Social Studies

Time Required

5-7 days (optional)

Process Skills

—analyzing
—collecting
—paraphrasing
—reading
—researching
—writing

Advanced Teacher Preparation

Obtain: As many resources as possible in the areas of geothermal, tide and ocean, fusion, wind, biomass, solar energy, and any other related resources.

Pamphlets and brochures from the Nebraska Energy Office.

Read: Energy Info—A Directory of Publications and Audio Visual Material from the Nebraska Energy Office.

Information included in this unit.

Goals

When students complete this packet, they should be able to make the following generalizations about energy:

1. Fossil fuel supplies are finite and rapidly decreasing.
2. Future energy alternatives have problems associated with them, both socially and environmentally.
3. Many of the well publicized energy alternatives have enormous barriers to overcome and may not be available for large commercial use until well past the year 2000.

Student Objectives

Students will be able to read about each future energy source.

Students will be able to choose a particular source to study.

Students will be able to record information about their topic and then compile this information in the form of a report.

Students will be able to identify at least two references in searching for information.

Planning Guide

Day 1
Explain to students the framework of this unit: to examine various alternative energy sources and to select one source for additional research. Read information on geothermal energy and provide students with a general description of this source.

Day 2
Read information on tide/ocean and fusion energy. Others may be read if time is available.

Day 3
Read remaining information about each alternative source of energy.

Day 4
Have students select one of the sources for further research. Time may be spent on giving students instruction for performing research.

Days 5-7
Students research their topics, gathering information from various sources, and begin to answer the five questions for their topic. Students then use their information in developing and writing a report about their particular source.

Evaluation Suggestions

Evaluation of this unit depends on how each activity is used and is therefore up to the individual teacher. As a suggestion, however, each student could be given specific guidelines to follow such as: listing specific aspects of their references—name of article, source, page number, date. Also, specific requirements as to use of correct spelling and punctuation in the final report, could be included.

Future Energy Technology

Geothermal
Tide and Ocean
Fusion
Wind
Biomass
Solar Energy

Instructor Information . . .

Rationale:

These readings give students some basic information about the following alternative energy sources: geothermal, tide and ocean, fusion, wind, biomass, and solar energy. This will provide students with possible choices for further investigation. Students may even suggest additional topics not listed.

Student Objectives:

Students will be able to read information about each energy source.

Students will be able to select a topic for further research.

Students will use their gathered data to complete a written report.

Implementation:

Begin by explaining the purpose of the unit. Have students read about each energy source, select one of their topics and begin to research on their own. Students should list the references they use in gathering data.

After information has been collected, students should develop a report based on some of this information.

The Instructor will need to provide time lines, additional requirements, examples, and other important information when necessary.

Debriefing:

As students begin to search and find information concerning their selected topic, it may be useful to have them share some of the findings orally with the rest of the class. Other options could include having students design or draw examples of their topics and having them work in groups to complete this task.

Name_____

Date_____

Introduction

Geothermal energy can best be defined as the natural heat of the earth captured by fluids trapped in rock formations thousands of feet below the surface of the earth.

In most areas, the heat source—molten rock or magma—lies too deep for its energy to be useful. In a few places in the world, though, the magma has worked itself relatively close to the surface, slowly transmitting heat to the layers of rock above it.

This is most likely to occur along the boundaries of the large mobile plates which make up the earth's crust. A good example is the Ring of Fire which encircles the Pacific Basin. Surface phenomena such as hot springs, geysers or fumaroles, along with sophisticated exploration techniques, can indicate to earth scientists the extent to which an area could produce geothermal energy.

Almost all of the known U.S. resources are located within the western third of the country. California, Nevada and Oregon have the highest concentration of known resource area. Alaska, Idaho, Montana, New Mexico, Utah and Washington have substantial potential. In fact, it is likely that the greatest thermal resources will always be found in the Western region.

Environmental Effects

One of the strongest arguments for the increased exploitation of geothermal power is that there are very few environmental problems associated with it. The most serious potential problem is that boron and other chemicals (which are mixed in with the geothermal water and steam) can cause damage if they are released into nearby waters or allowed to escape into the atmosphere. It is hoped that this problem can be solved by simply re-injecting these chemicals back into the well. The other major hazard is that of land subsidence from the withdrawal of large amounts of water, but again, it is thought that this can be controlled by limiting withdrawals to a safe rate and by re-injecting water into the wells, a practice currently used in many oil drilling operations.

There is some worry that earthquakes may be triggered by re-injected water under pressure. Less significant, but still "nuisance" problems, have to do with the odor of hydrogen sulfide which is released during exploration (the familiar rotten egg smell). This can be a serious health hazard, particularly to drilling crews, if allowed to reach high concentrations. There is also considerable noise involved as steam rushes out of the well at supersonic speeds, often exceeding 100 decibels when a well is vented. Finally, large land areas are required—between 3,000 and 5,000 acreas for a 1,000 Mw plant, with about 7 to 10 percent of this used directly for facilities, a large part of which are an unsightly jumble of pipes. However, the geothermal generating plants appear to present less environmental threat than either nuclear or fossil fuel plants, and the problems that do exist are highly localized and seem to have available solutions.

Summary

On a nationwide basis, experts believe that there is a geological opportunity to develop enough geothermal energy production to power twenty million kilowatts of generating capacity in the next two decades, equivalent to about 700,000 barrels of crude oil per day.

Developing this important energy source would result in major foreign exchange savings and reduce dependency on foreign energy sources.



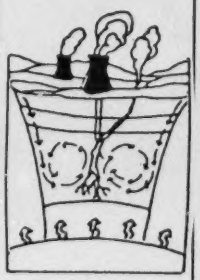
GEOTHERMAL

Ring of Fire

location of thermal resources

few environmental problems

nuisance problems

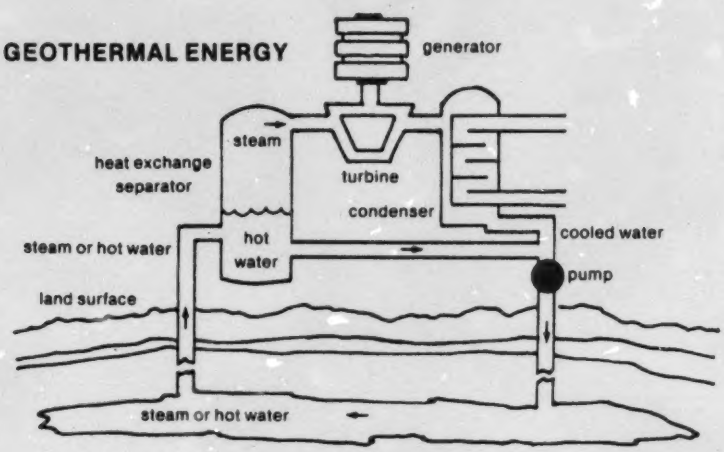


Geothermal energy from deep in the earth's crust can be tapped to generate steam power in some selected areas.

Name_____

Date_____

Future Energy Topic:_____



Directions: Using as many sources as possible, find and record information for the following questions:

1. WHERE can this resource be found?

2. HOW is this resource used?

Name_____

Date_____

3. WHAT are some **advantages** for developing this resource?

4. WHAT are some **disadvantages** for developing this resource?

5. HOW expensive and/or practical is this resource?

Name_____

Date_____

References used (name at least two)

1. _____

2. _____

3. _____

4. _____

Report on_____

Name_____

Date_____

Introduction

Scientists are trying to use the rising and falling tides, the ocean's waves and winds, its currents and temperature variations to harness nature's enormous energy and turn its kinetic forces into additional useful tools for mankind.

The world's largest solar collector is the sea, which makes up 70 percent of the earth's surface. Enormous quantities of solar energy are collected and stored in the world's oceans. Scientists and engineers have long been intrigued by the possibility of harnessing this source of energy for humankind.

Scientists have found at least eight different energy possibilities in the seas that surround us. Some are more promising than others. All require lots of investment in time, technology and money to construct and operate the facilities that will convert nature's forces into new means of energy production.

All have this in common: they are self-renewing—a major consideration in a world of finite mineral resources. And with research and careful application, all could be environmentally acceptable.

Tides and Tidal Currents: The flow and ebb of tides in and out of restricted areas can be harnessed and used to turn turbines for electrical energy and drive water wheels for mechanical energy.

Ocean Thermal Energy: There's a great difference in temperature between the sun-heated surface waters and the cold waters deep beneath the surface of any ocean. This temperature differential can be used to power the turbines that produce electricity.

Ocean Waves: Movement of waves can also be converted into turbine power to generate electricity.

Ocean Currents: As tides can spin turbines, regular ocean currents, such as the Gulf Stream and Japanese Current, can be used in turning underwater turbines.

Ocean Wind: "Windmills," both floating and stationary, have been considered as a way to use the natural airflow of onshore and offshore breezes to turn electrical generators.

Salinity Gradient Power Systems: These systems release energy when fresh water from rivers enters the salty water of an ocean.

Kelp Bioconversion: Sunlight and ocean water can be used to grow kelp—a seaweed that "captures" the sun's energy. Scientists hope to produce fuels, livestock feeds, chemicals and fertilizers by processing this ocean product.

Ocean Geothermal Power: Man has developed the means to use some of the near-surface heat of the earth's core to spin electrical generating turbines at the Geysers in California north of San Francisco. In much the same way, the near-surface heat under the oceans could also be used to develop electricity.

Ocean thermal energy conversion—called OTEC for short—has caught the eye of officials in Washington. It promises to be a supplemental source of energy that could be tapped to help ease the pressure on our declining petroleum reserves. Congress increased its funding of various OTEC projects from $100,000 in 1972 to $40 million in 1980. More than 200 private contractors currently are working under Department of Energy (DOE) guidance in ocean energy research and development activities. These include the design of test facilities and the construction of offshore and onshore pilot plants.

Environmental Effects

It is even more difficult to anticipate environmental problems associated with OTEC plants than to estimate the economic factors. Compared to coal-fired or fission plants, however, the environmental impact should be fairly benign.

A long-term concern of a successful and large-scale OTEC program is the effect of a possible change in the temperature characteristics of the tropical ocean. Climate changes can be

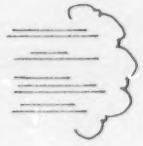
harnessing nature's energy



TIDAL

self-renewing

temperature differential



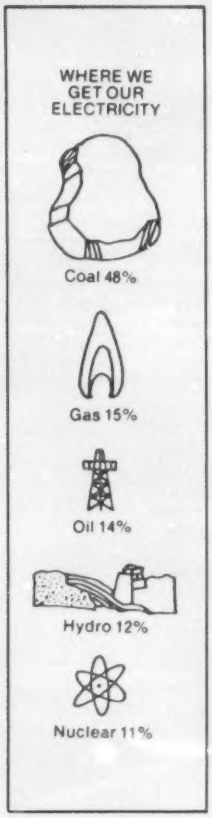
WIND

Electricity

OTEC testing

possible changes in ocean temperatures

advantages and disadvantages



influenced by changes in atmospheric or oceanic temperatures, but there is little evidence as to how serious a given change in the surface temperature would be. This is an important area for further study. However, it is a distant concern since generation of the entire electrical requirements of the U.S. from the thermal energy of the Gulf Stream would cause a drop of only a fraction of 1°F.

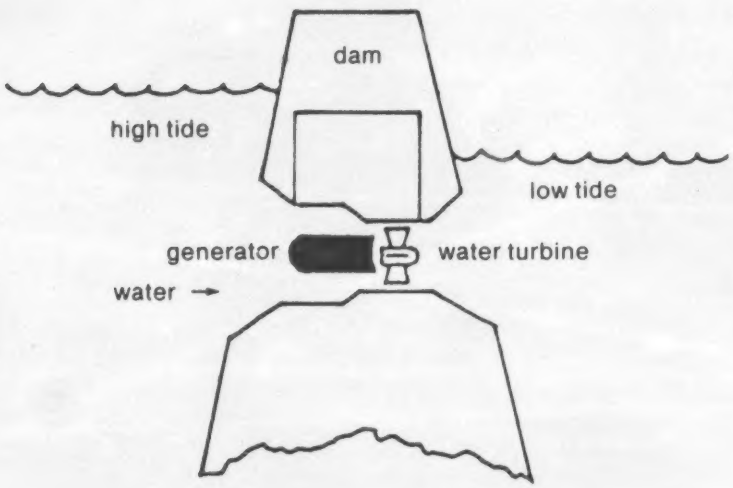
There are both potential advantages and disadvantages associated with pumping large quantities of cold water to the surface. These waters are rich in nutrients and might, therefore, allow the establishment of fisheries around the plants. The practice would definitely distort the ecological balance, and the new balance must be anticipated and understood. In particular, it would be important not to disrupt the natural life cycles of oxygen-producing algae.

The cold water, however, also contains large amounts of dissolved carbon dioxide which would be released upon warming. Preliminary calculations show that the production of 1 kw-hr of electricity by an OTEC plant would release about one-third as much carbon dioxide as released by the present burning of fossil fuels for the same purpose. Since the change in atmospheric temperature due to the "Greenhouse Effect" brought on by an increase in atmospheric CO_2 is one of the long term outcomes, continued study and a search for ways to lower this effect of OTEC plants will have high priority.

Summary

Some major problems have yet to be overcome. The present cost of some of the equipment is very high, while the efficiencies are low. For example, DOE estimates that an OTEC plant, using present technology, would cost about $2,000 per kilowatt, as compared with $800 to $1,000 per kilowatt for coal plants. And there's a problem in stopping microorganisms from gathering on the equipment, as well as inside it, thus reducing its efficiency. But, if a way is found to solve the technical and cost problems, a significant step could be taken in finding a self-renewing, non-polluting electrical power source for the future. It will be a number of years before any of these proposed tidal and ocean energy systems become practical—from either an economic or a technical standpoint.

TIDAL POWER



15

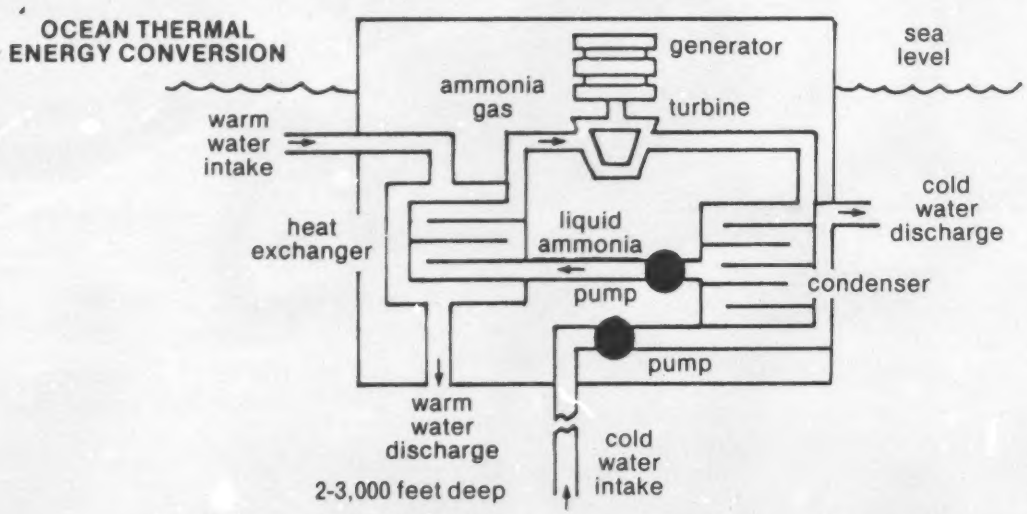
Future Energy Technology

Activity #2,
Student Worksheet, Page 1

Name_____

Date_____

Future Energy Topic:_____



Directions: Using as many sources as possible, find and record information for the following questions:

1. WHERE can this resource be found?

2. HOW is this resource used?

Name_____

Date_____

3. WHAT are some **advantages** for developing this resource?

4. WHAT are some **disadvantages** for developing this resource?

5. HOW expensive and/or practical is this resource?

Name_____

Date_____

References used (name at least two)

1. _____

2. _____

3. _____

4. _____

Report on_____

Name_____

Date_____

hydrogen is plentiful



SOLAR

plasma—the gas of electrons

holding generated heat

trapping radioactivity

a significant advantage

environmental protection

more work is necessary

Introduction

Fusion, which is the power of the sun and other stars, is one form of energy being developed for electrical power production. The process can be safe, environmentally attractive, and best of all, the supply of deuterium and tritium, two isotopes, or varieties, of hydrogen, which would be the basic fuel for fusion, are plentiful. Deuterium exists in great quantity in ordinary water and tritium can be produced in a fusion reactor from lithium, an element found in granitic rocks and underground salt water.

If the energy in the deuterium in the Pacific Ocean were used to fuel fusion reactors, it would provide enough energy to generate electricity for the entire world for billions of years.

Fusion is the process by which the sun generates its energy. The sun is a very hot gas; in fact, it is so hot that atoms in it have ionized. This means that the negatively charged electrons have become separated from the positively charged nucleus (called an ion) of the atom.

The gas of electrons and ions is called a plasma and has some very special properties. One of these properties is that the ions frequently collide with each other. The hotter the plasma, the harder they collide.

If the plasma is hot enough, then the ions will collide with enough force to overcome their tendency to repel each other due to their positive electric charge. When this happens, these ions or nuclei combine or fuse to form new nuclei (new elements) and release energy in the process.

What is needed is a way to generate a very hot plasma, like the sun, and hold it together long enough for many fusions to take place and release much energy. The major problem facing researchers is how to hold and heat this plasma in a suitable container so that the ions, which are moving more than a million miles per hour, will not strike the walls and lose their energy.

Environmental Effects

Future reactors will not contain the huge amounts of radioactive material characteristic of fusion reactors. Tritium will be produced, but the entire system will be designed to recapture and consume this material and its stockpile, even if released, presents much less of a threat than the fusion products. Radioactivity will be produced in the reactor materials by the neutrons and, while this may be a problem, it probably can be reduced by proper choice of construction materials.

Perhaps the greatest relief that successful fusion power generation could offer us would be from the plutonium nuclear bomb threat. Unless neutrons from fusion reactions were deliberately used to breed plutonium from uranium 238 (as has been proposed), no potential bomb making materials would be produced, transported, etc., a very significant advantage.

The production of fusion fuels, because of the enormous amounts of energy they contain, should cause little disruption of the environment. Removing one hydrogen atom in 6500 from the ocean will have no measurable effect on it and the amount of lithium needed is equally miniscule when compared to projected needs of coal or even uranium.

The fusion reaction would be, it appears, as environmentally benign as any technology except solar energy.

Summary

The fusion reaction, relying on abundant deuterium for fuel, could provide humankind with energy for millions, perhaps billions of years and at modest cost to the environment. Unfortunately, in spite of almost 30 years of scientific and engineering labor, and a billion or so dollars spent in the U.S. we have not yet produced a self-sustaining, controlled reaction.

The present challenge of fusion is to confine the D-T mixture of sufficient density, hold it together long enough, and get it hot enough to cause the reaction to occur. This accomplishment will demonstrate the "scientific feasibility" of a self-sustaining fusion reaction. Even after this is achieved, however, a host of problems will remain. A very complicated piece of machinery will have been constructed: large vacuum chambers, huge magnets (which may

be "super conducting" magnets cooled by liquid helium) and tanks and pipes of extremely hot lithium. There will not only be enormous differences in temperature to sustain, but all of this equipment will be bombarded by an enormous flux of neutrons which will not only create radioactivity, but may weaken the metallic structures. These engineering challenges may be as great as the scientific ones. Beyond them remain the economic challenges. Can all this be constructed cheaply enough before breakdown to produce electricity at a competitive price?

continuous challenges

magnetic fusion

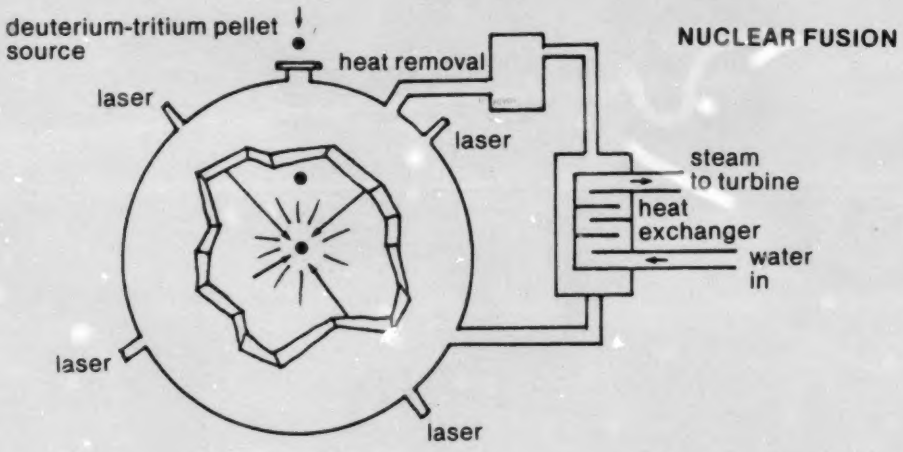


FUSION

Name_____

Date_____

Future Energy Topic:_____



Directions: Using as many sources as possible, find and record information for the following questions:

1. WHERE can this resource be found?

2. HOW is this resource used?

Name_____

Date_____

3. WHAT are some **advantages** for developing this resource?

4. WHAT are some **disadvantages** for developing this resource?

5. HOW expensive and/or practical is this resource?

Name_____

Date_____

References used (name at least two)

1. _____
2. _____
3. _____
4. _____

Report on_____

Name_____

Date_____

Introduction

Wind. A devastating Power. Feared through the ages for its awesome destruction. A subject of romantic song and myth. And a practical energy source.

The practical side is not out of character. In fact, wind is one of man's oldest energy sources. At least 5,000 years ago, the Egyptians used sails on their Nile River craft. The Persians, in 100 B.C., used wind turbines to grind their grain. Through the centuries, others have used wind for similar tasks.



WIND

Engineers, knowledgeable in the recent advances in aerodynamics and airfoil design, are showing increased interest in wind power and researchers are experimenting with many types of wind machines. Some are like farm windmills. Some look like multispoked bicycle wheels. Others are more like propellers or wheels with paddles. Still others are vertical-axis turbine or airfoil machines that look like eggbeaters. Another type is similar to the open-cupped anemometer found on garage roofs or airport control towers to measure wind speed.

wind machines

Researchers are trying to: (1) improve the technology and reduce the cost, and (2) develop economical ways to store or "even out" the energy produced by wind machines.

If wind power is converted to electricity, some of it can be stored in batteries. But only a small portion. Significant improvements in battery storage capacity and cost are needed.

storing wind power

Wind machine energy can, through friction, be converted to heat. The heat can be stored as hot water or in other substances.

The machine can also be used to pump water to a higher level of storage and later released when the force of gravity will cause it to propel generators for production of electricity. In other words, a pumped storage reservoir plant.



Finally, the wind machine could be connected directly to a conventional energy system to reduce storage requirements and provide supplemental capacity in order to supply consumers with continuous electrical energy at the most advantageous cost.

Environmental Effects

Because wind machines are relatively passive "low technology" machines, there are no direct by-products or residues to dispose of and the secondary effects of their manufacture are not especially troublesome.

no direct by-products

Their major drawback is land use. Although a single machine does not occupy much space, a giant grid of them complete with power lines would have aesthetic drawbacks, but wind harvesting should be compatible with other uses of the land such as pasturage and farming.

The efficiency of land use is also expected to be comparable to farm use. If "solar efficiency" is defined (for a large area windmill farm) as the ratio of power output from the windmills to the solar-power incident on the land they occupy, it is estimated that efficiencies of about 5 percent are possible in the Great Plains area. Photosynthetic efficiency of growing plants is about 1 percent.

If really large-scale use becomes a reality, there will be questions to answer about possible effects on weather caused by the removal of large amounts of kinetic energy. In general, however, wind energy, like other forms of solar energy, seems to be environmentally benign.

environmentally benign

Wind power development has been held back so far by economic considerations. Proponents insist, however, that once development is past the pilot plant stage and components are mass produced, wind power generators will be competitive with fossil fuel and nuclear plants. A recent comparison estimates the cost of building wind power generating plants at $150-$200 (in 1974 dollars) per installed kilowatt. The wind power system suffers because it is at full capacity only 25 percent of the time on the average, while coal and nuclear operate at 50 to 60 percent load factors. However, the low load factor of the wind machine is compensated for by low maintenance and zero fuel costs. The total cost of its electric is projected at 2 or 2-½ cents per kw-hr—about the present average cost of electricity produced by conventional power plants. Given the early stage of development, this is an encouraging picture.

as always consider the economic situation

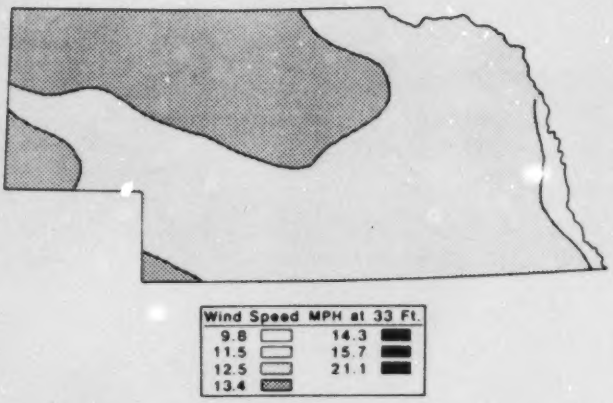
Summary

What is the future of this appealing concept of wind energy? On a national basis, the total contribution will likely be quite small.

Nevertheless, wind power—along with other renewable energy sources can be useful in specific locations and through properly designed applications can thus help to reduce our present heavy dependence on foreign oil.

WIND INFORMATION

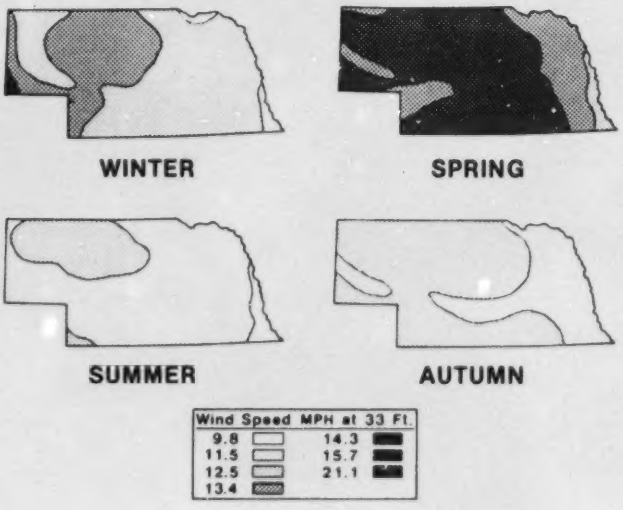
Nebraska Wind Data



Nebraska Annual Average Wind Data

In Nebraska, the strongest average winds blow in the northern and western parts of the state. Most of the rest of the state shows an average wind speed that could adequately support wind systems.

Nebraska Seasonal Average Wind Data

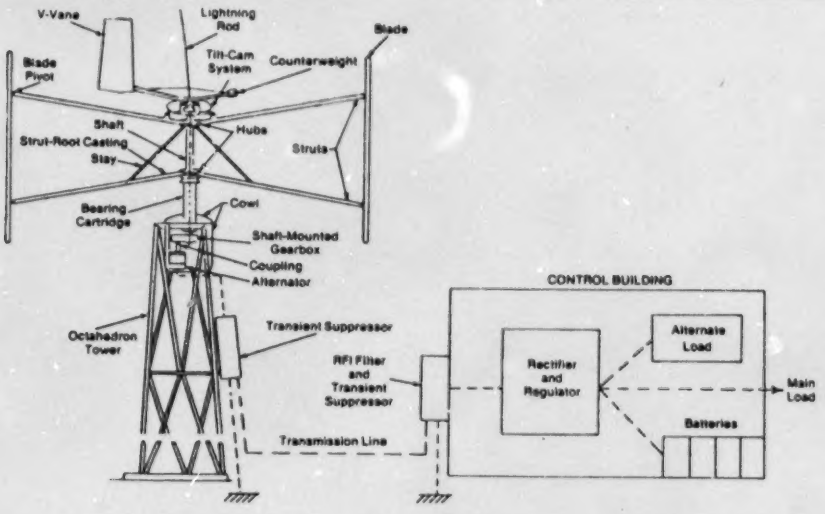


Nebraska's wind patterns are similar during the four seasons though velocities vary. Winter and spring produce the strongest winds.

Name_____

Date_____

Future Energy Topic:_____



Directions: Using as many sources as possible, find and record information for the following questions:

1. WHERE can this resource be found?

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Name_____

Date_____

3. WHAT are some **advantages** for developing this resource?

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References used (name at least two)

1. _____
2. _____
3. _____
4. _____

Report on_____

Name_____

Date_____



BIOMASS

filling a small component of our energy needs

bioconversion

usable energy

manageable problems

striking a balance

turning organic waste into energy

conversion of waste

Introduction

Biomass encompasses wood chips, sawdust, corn stalks and other vegetable matter. It also includes municipal waste and organic wastes. Some organic matter can be converted into alcohol. Other disposed of materials can be pelletized to become a fuel which some see as the ultimate solution to our solid waste disposal problem. Everything recycles.

Burn it, distill it, refine it or allow it to decompose in order to produce energy.

Sounds simple, but it will take time to perfect the process and to build the facilities to make biomass energy widely and economically available. Even then, it's likely that biomass conversion into energy will fill only a small component of our total energy need. While the potential for biomass fuel is considerable, government and industry estimates suggest that biomass energy production will supply the equivalent of just 200,000 to 300,000 barrels a day of oil by 1990.

Biomass is another indirect form of solar energy. The sun's energy, stored as chemical energy in organic plant life, can be converted into usable fuel by a variety of means.

Three ways to turn biomass into usable energy are:

1. Burning biomass products, such as wood. This is the best known, oldest and probably least efficient method. But it works and many home builders are adding wood-burning stoves to their new homes as an energy saving feature.
2. Thermochemical conversion. This method can produce synthetic gas, fuel oil, methane and petrochemical substitutes.
3. Biochemical conversion. This includes the fermentation of starches and sugars in plant life to produce alcohol and the anaerobic (lacking oxygen) digestion of animal manures, woody and soft-stemmed crops to produce biogas, or liquid fuels such as alcohols, fuel oil, ketones, and higher alcohols.

Environmental Effects

There will be some environmental problems, no doubt, but these appear to be manageable. Organic waste is typically low in sulfur, reducing that problem. Nitrous oxides will be produced, as always, when combustion occurs in the air, and there will be particulate matter requiring removal, but the ash problem is much less than that with coal. There will be sludge to dispose of and water to purify, but viewed against our present waste problems, these problems do not loom large.

If we consider large scale energy conversion of agricultural and crop residue, some balance will need to be struck between energy needs and the needs of the soil. Manure and crop residues may, for instance, return more value if put back into the soil to replace the fertilizer (which has dollar and energy value), and to maintain proper soil texture. In the end, these decisions are economic. The residues—forest or agricultural—belong to the producer and he will give them away, sell them or use them in the manner which brings him the most economic benefit. It will probably be left to society to provide for the necessary long term protection of the soil.

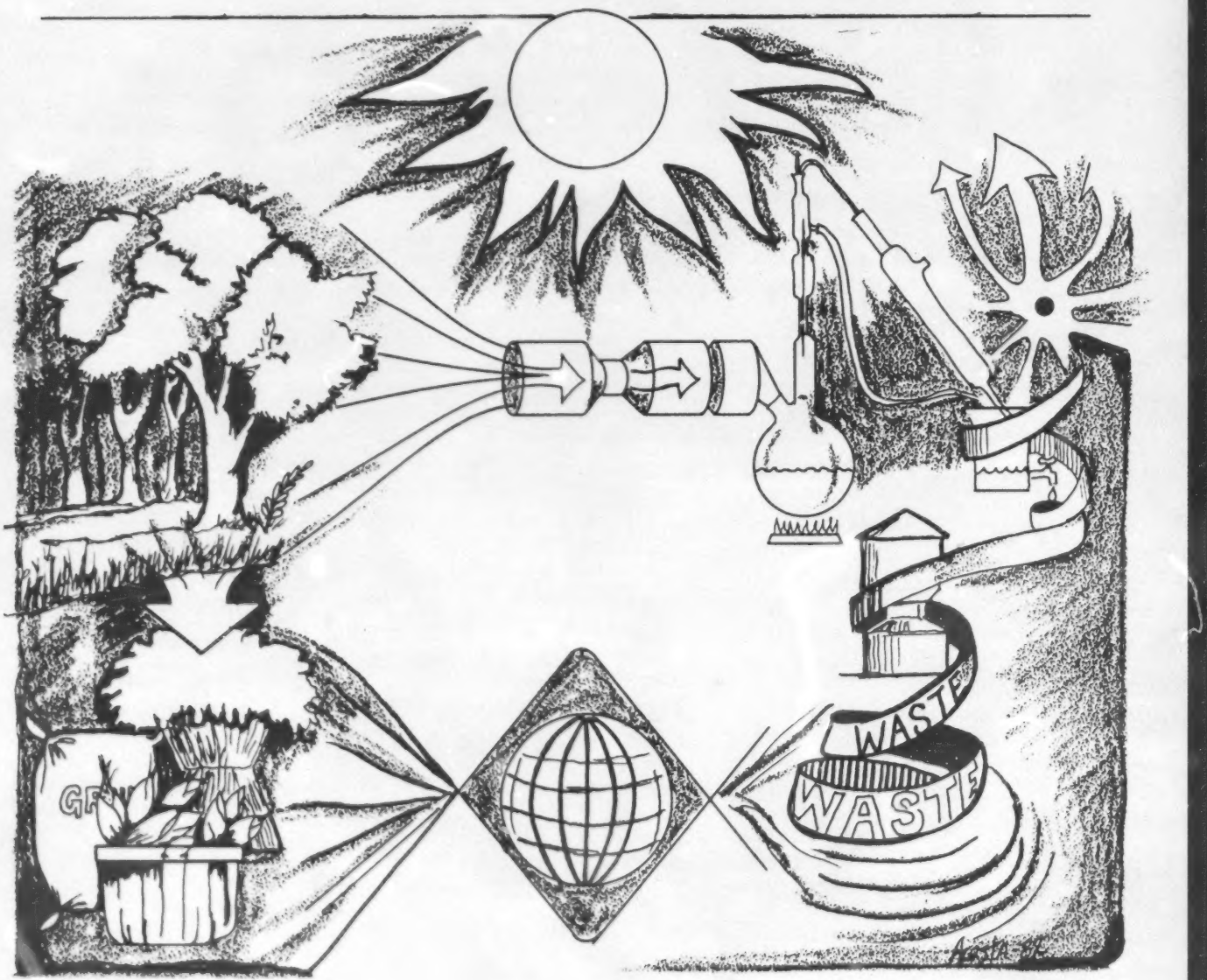
Summary

Organic wastes represent an important supplementary fuel source for the future. The total potential resource is large. If all the 1971 waste had been converted to energy it would have satisfied 13% of the total energy demand and 44% of the total electrical demand. The amount that can be economically converted is considerably smaller, however, and would provide only 1 to 3 percent of the total energy.

Conversion plants will need pollution control devices, but generally their contribution to pollution would be lower than the fossil fuels. Furthermore, the conversion of waste would significantly reduce the serious disposal problems which already exist.

In the enthusiasm for trash-to-energy conversion, however, one should not forget that the trash, the raw material, is waste. While these conversion techniques described do reclaim some of its energy potential, greater gains can be achieved by avoiding its creation in the first place. A styrofoam cup reused, for instance, saves more energy than can be obtained by burning it for fuel if the energy cost of replacing it is considered. The combination of reducing the amount of waste and waste conversion, however, offers important future energy savings.

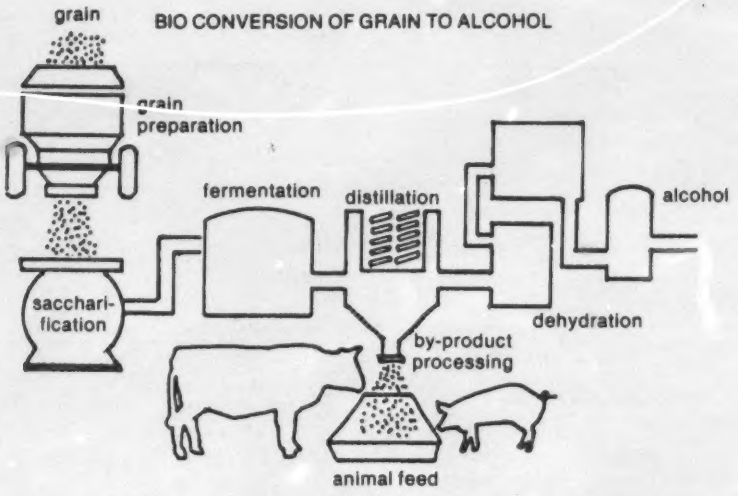
trash-
to-energy



Name_____

Date_____

Future Energy Topic:_____



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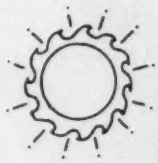
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Report on_____

Name_____

Date_____

Introduction



SOLAR

Some day in the future the sun can be the final answer to our energy needs. But, until that day arrives, a more attainable goal would be to make solar energy a more efficient answer.

The rudiments of solar power are being applied more purposefully now, even though they have been known for centuries.

New housing construction takes advantage of the sun's warming rays in winter. Architectural design and improved insulation materials to protect us from its blistering effects in summer, are also taken into consideration.

These are passive uses of the sun's radiance. But, how do we get it to do what **we** want, **when** we want it?

converting the sun's energy

That's where technology, imagination and enterprise come in. We are learning how to concentrate the sun's power and convert its energy into forms that can be stored, transmitted, focused and applied where and when they are needed, and not simply where and when they occur.

Direct use of the sun's rays for heating, growing, boiling or burning is well established.

Now, more attention is being paid to indirect means of producing electricity, heating water or some other dense materials such as rock, ceramic block or volatile fluid.

converting to electrical energy

In addition, the direct conversion of sunlight to electrical energy through the use of photosensitive materials is under intense study. It works right now, on a small scale—in the space shuttle, for example.

Consider, a photovoltaic system is based upon technology discovered as long ago as 1829. Electrons within a semiconductor such as silicon absorb sunlight or photons, and are then freed to move. This movement produces a direct electrical current.

photovoltaics

The most appealing part about photovoltaics is that the process is direct—no middle man—sunlight into electricity, without boilers, turbines, generators, pipes or cooling towers. The system is almost maintenance-free, once installed. And because it operates on diffuse radiation such as we experience with sunshine, it can operate where the sun's rays are not intense.

need for space

It does require large amounts of space, however. For example, to generate a megawatt (one million watts) of electricity, using today's technology, requires 10,000 square meters of solar cell area. If that area were stretched out, it would be more than a yard wide and over six miles long.

For that reason, major technological breakthroughs will be needed before photovoltaic conversions can be used on a practical, everyday basis.

Environmental Effects

land use

Solar cells have a generally benign direct environmental impact. The largest problem is the amount of land needed. If a target generation of 1 x 10 kw-hryr. is chosen (a reasonable target for early in the next century), then about 0.1 percent of the U.S. land will have to be dedicated to this purpose. This huge amount of land—20 million acres—covered with 10 percent efficient solar cells would produce about 6 percent of all electric energy we expect to use in 2020. It is a lot of land, but highways now cover five times as much land and crop land is 100 times larger.

an indirect impact

There will be significant indirect environmental impact. The energy to process the millions of solar cells will inevitably add to the environmental burden. It may take years, as it did in the nuclear industry, for energy production by solar cells to catch up with the energy expended in their construction.

Summary

Photovoltaic conversion of sunlight to electrical energy is presently accomplished, but at a high price.

continued need for technological improvement

Mass production techniques from sand to cells, new methods of growing silicon ribbons, use of new materials, including polycrystalline materials and glass, and types of cells which use other effects than the (positive-negative) p-n junction should eventually lower prices. In addition to the research, there are equally difficult problems of installation, storage, utility interconnection, etc., to be solved.

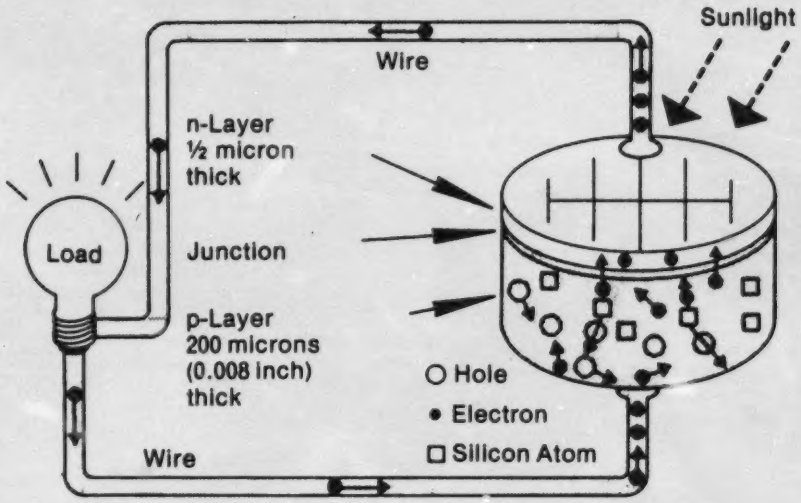
The American people are turned on to the idea of free energy from the sun (at almost any cost, apparently), and the solar era may dawn more brightly and quickly than expected.

Future Energy Technology
Activity #6,
Student Worksheet, Page 1

Name_____

Date_____

Future Energy Topic:_____



A Solar Cell at Work

Sunlight penetrates the ½-micron-thick n-layer (a micron is one-millionth of a meter) and liberates electrons near the junction of the two layers. These electrons are collected by the wire attached to the front of the cell and can be used as ordinary direct current to do work.

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Report on_____

SUPPLEMENTAL MATERIALS GUIDE

1. **Energy Adventure,** Amoco Teaching Aids, P.O. Box 1400 K, Dayton, Ohio 45414 (Teaching spirit masters, units).

2. **Energy Info—A Directory of Publications and Audio Visual Materials From the Nebraska Energy Office.**

3. **Fact Sheet.** Fowler, John M. and Kathryn, National Science Teachers Association, U.S. Department of Energy, 1-19.

4. **Magnetic Fusion.** U.S. Department of Energy, 1978.

5. **Supplementary Energy Sources.** American Petroleum Institute, August, 1981.